Space Weather Technical Forecast

Issued on Saturday, 18 March 2023 at 00:45 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Several large filament eruptions observed - analyses pending.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity rose to Moderate over the past 24 hours, with X-ray flares recorded at GOES16 peaking at M1.0 at 17/1507UTC. This peak comprised of an impulsive flare from AR3254 in the southwest, overlaid on a much longer-period C6 flare from AR3256 in the southeast.

In terms of sunspot groups, there has been a reduction in the front-side population in the past 24 hours, with just three surviving groups: AR3256, an arriving Dho/Beta (at least) on the southeastern limb; AR3251, a stable Hsx/Alpha in the southwest; and finally AR3254, a Cro/Beta also in the southwest.

Solar activity has been dominated by filament eruptions in the period - most notably a 30-degree longitude spanning filament leaving the southwest disc at 17/1100UTC, angled largely ahead and below of the Sun-Earth line. This left a long filament arcade in its wake and has been clearly visible in subsequent coronagraph imagery. A pair of smaller filaments then lifted off the northwest disc at 17/1800UTC and 17/2100UTC, capped by a much larger limb-ward prominence eruption in advance of AR3254 at 17/2200UTC.

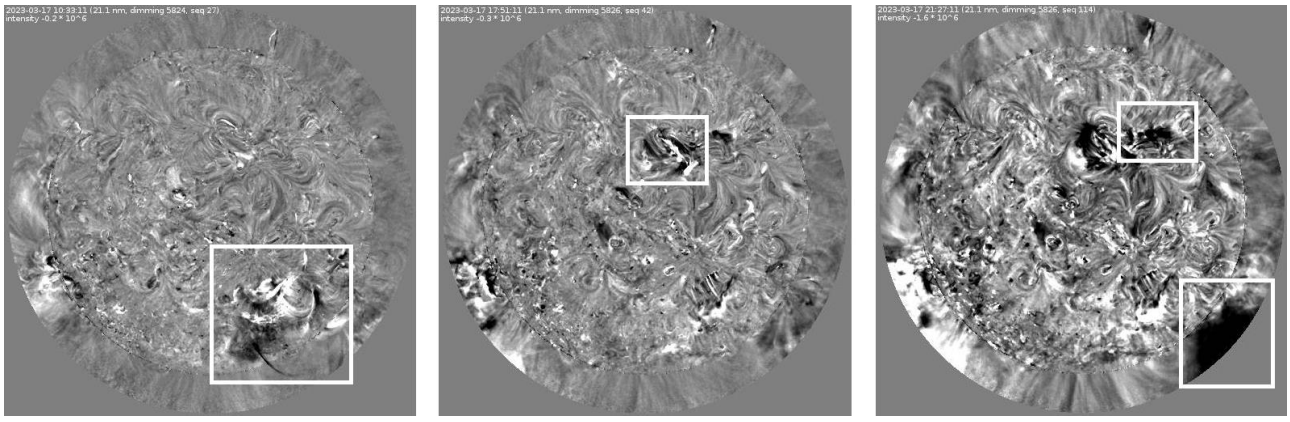

Figure 0: non-exhaustive rogues' gallery of time-integrated EUV imagery (AIA211), showing at least four front-sided filament lift off and dimming events. Only the leftmost has so far been accounted for and analysed. Image processing courtesy of SIDC ROB.

At the time of writing only the first of these filaments has been analysed, with the result being a miss ahead of and below the track of the Earth's orbit (crossing 1AU around the turn of the UTC day 20 into 21 March). Keeping abreast of the forecast is advisable for the remainder, with Earth-directed components considered a possibility for both the northwestern lift-offs, should imagery

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confirm that they have indeed left the immediate solar environment. The geomagnetic forecast is therefore of lower than average confidence in the meantime.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1 showed a decline through Slightly Elevated levels, falling from an early high near 475 to reside nearer 425km/s by the period's end. This may be the death throes of coronal hole 84 given the continuing positive phi angle (away from the Sun).

The solar wind density was level within its typical range of single figures ppcc, while the IMF was stable at or below 6nT, with the north-south component ranging between +/-5nT.
The net result of the above solar wind measures was for provisionally Quiet geomagnetic actvity throughout, peaking at Kp '2-' between 06 and 15UTC.
Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 has continued a slow decline after the 13 March enhancement, currently about double its resting flux, but still only fractions of a pfu at GOES16, and well below 10pfu or S1.
The high energy electron flux (greater than 2MeV) has been at mostly Normal Background levels. The associated 24-hour Electron fluence has been well below Active, albeit with a slightly increasing trend. At 18/0001UTC the observed fluence was 2.9e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Chance of M-class activity, primarily from AR3256 near the southeastern limb, which is likely to be hiding detail. This risk may be bolstered by further arrivals in the four days.

Solar Wind / Geomagnetic Activity: No CMEs currently feature in this forecast, although note the 'Solar Activity' section and some unanalysed candidates. The geomagnetic forecast is therefore of lower-than-average confidence pending imagery.

The geomagnetic forecast currently comprises the onset of one fast wind regime, that emanating from CH85/+, and with this feature mooted for arrival on Monday 20 March. There is a peak Slight Chance of G1 for the four-day period on this day, with preceding activity largely Quiet, and following activity Unsettled or perhaps Active, but relaxing before midweek UTC.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to continue its gradual decline, with a very slightly raised residual risk until this is completed - perhaps by the end of the current UTC weekend.

The high energy electron flux is expected to persist at largely Background levels, with perhaps a slight rise early in the period, probably then arrested by any fast wind from CH85/+ before reaching a second peak midweek, i.e. after the end of this forecast period. Even at peak, the chances of reaching Active fluence are considered Slight.

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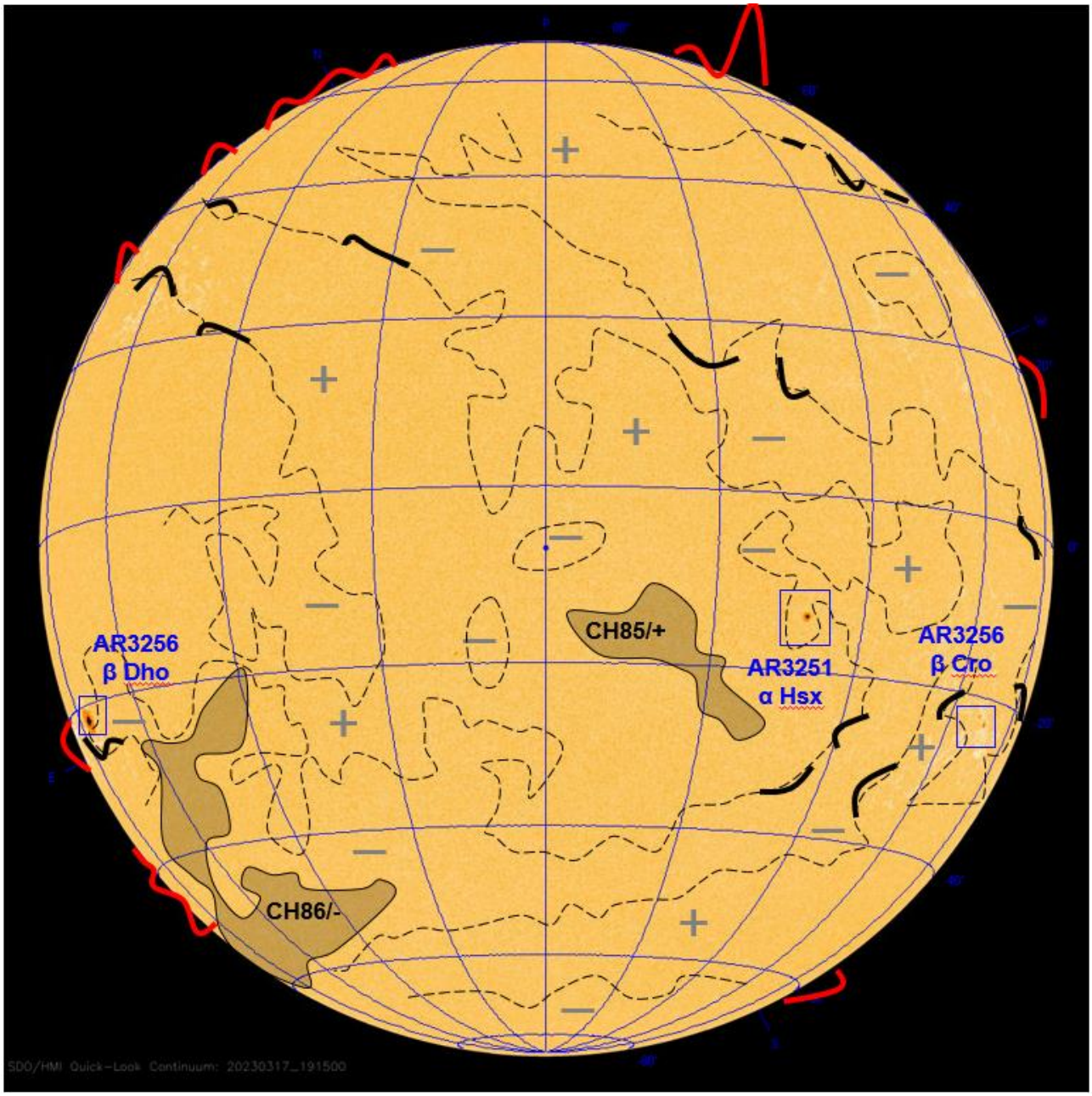
Figure 1. Solar Analysis Valid 17/1915UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No CMEs feature in this forecast period.

The sole fast wind enhancement due in the four days is CH85/+, which manifests on the disc as a small, similarly-sized and positioned feature compared to its last pass, when solar winds reached 450km/s. Given this modest potential and its unfavoured magnetic polarity for the Spring equinox, CH85 does not appear likely to be a significant coronal hole feature, perhaps leading to a Slight Chance of G1 at peak into the new UTC working week.

Geomagnetic activity should be Quiet over the coming UTC weekend, peaking with the aforementioned Slight Chance of G1 on Monday 19 March, before giving way to Unsettled or perhaps isolated Active intervals at first Tuesday, but waning by the end of the four-day forecast.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil, but note unassessed candidates detailed in ‘Solar Activity’ section.

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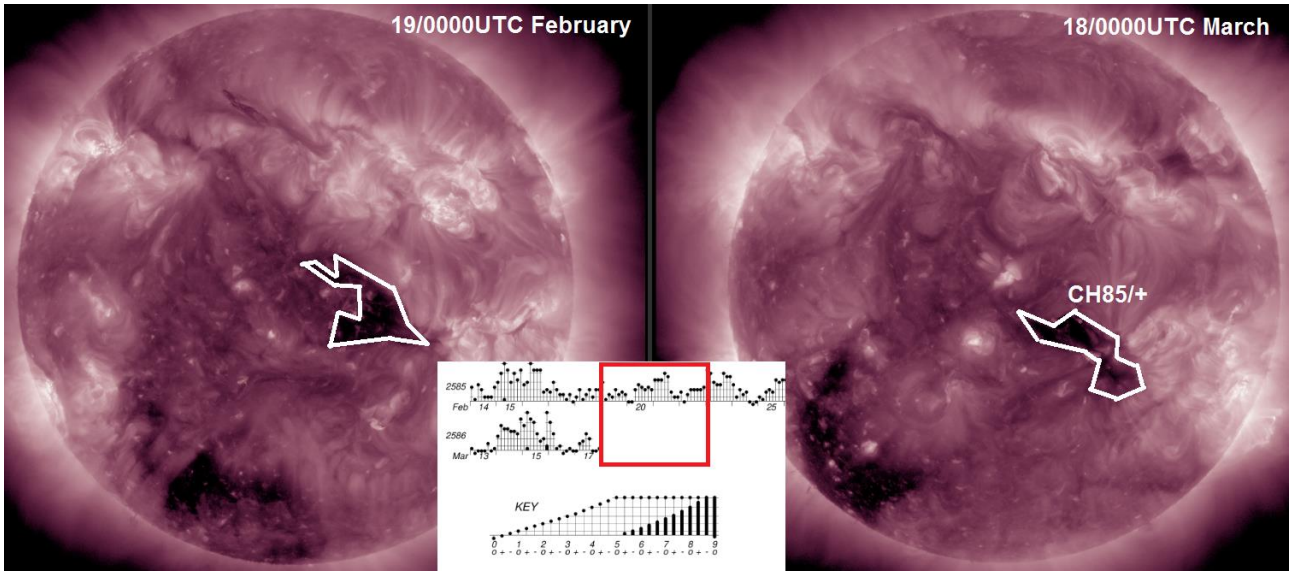
Figure 2: Comparison of current (right) and previous (left) rotation geometry of CH85/+ (in AIA211) and its resulting effects (after Bartels, inset).

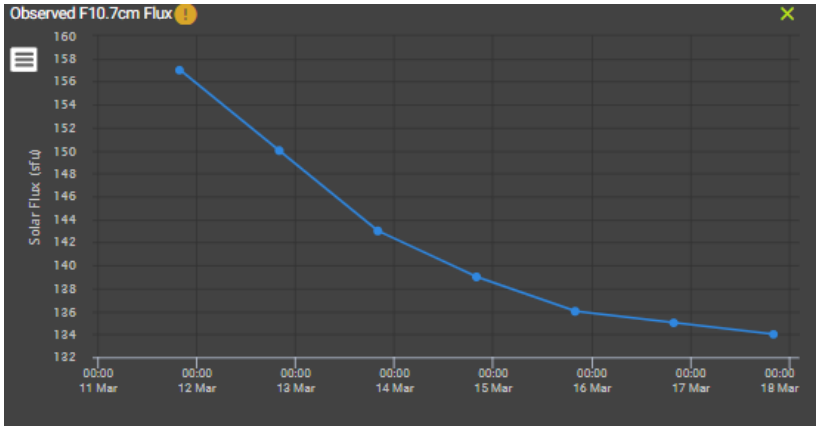


Radio Blackouts - X-Ray Flares:

Solar activity rose to Moderate in the past 24 hours.

Sunspot numbers have fallen sharply over the past week, as evidenced in the Penticton 10.7cm flux, which has consistently fallen from a high of 157sfu on 11 March to reach 134 as of 17 March. While there is no evidence that this may be maintained, it is possible that the Sun is going through something of a lull in its otherwise inexorable rise towards solar maximum. There now remain just three numbered front-sided spots, and of these only one carries any apparent complexity - AR3256 near the southeastern limb.

Figure 3: Seven-day trend in Penticton 10.7cm flux, a proxy for the tied overall decrease in sunspot numbers observed in the period.



This group's proximity to the Sun's edge is currently impairing analysis, however it is very possible that the plage may contain further spots beyond the already discernible large symmetric penumbral leader and a very small trailer. For this reason, its current appearance of Dho/Beta is flet likely to be a best-case, and the values for X-ray flare risks have been tuned higher than raw values for this Zurich class would suggest.

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On the western horizon, the more subdued AR3254 is due to leave the Earth-facing disc by the end of the current UTC weekend, although this is felt to offer little to the risk of flares. The Carrington locations for up to three further returning sunspot regions are perhaps then due in the period, which makes for a tentative negative outlook, all else being equal. Until any new regions arrive, the current daily Chance of M-class flares and Slight Chance of X is maintained throughout.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	25	25	25	25
Very Active	R3 to R5 X	No	5	5	5	5

Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10 MeV) proton flux, as observed by GOES16, remains a little above its resting background rate as a result of the full-halo far-sided CME of 13 March. So, while there are no obviously potent sunspot regions near the better-connecting western limb, the fact that there may remain a region on the far side capable of such enhancements and the fact the protons have yet to return to their typical counts, both make S1 very slightly more likely in the near-term, with this risk reverting to 1% (i.e. finally relaxing to the raw disc probabilities) thereafter.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	1	1
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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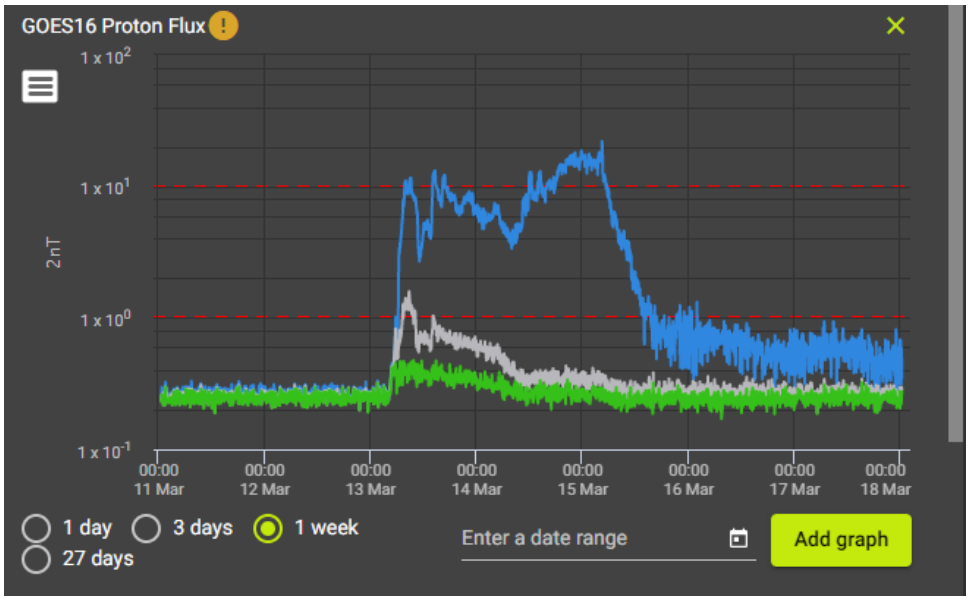
Figure 4: The past week in GOES16 10, 50 and 100MeV protons, showing a strong reaction to an event near 180W, and a subsequent very gradual decay that is continuing at the time of writing.



High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2MeV) electron flux as observed by GOES16 at GEO, is expected to persist at largely Background levels. There has thus far not been any significant upward reaction in flux in the wake of the 15 March CME arrival(s) and the CH84/+ fast wind. With geomagnetic activity from both now having waned, and with the solar wind speed having fallen from Elevated to Slightly Elevated levels, electrons ought to reach a new diurnal oscillation level shortly.

The probabilities of Active 24-hour electron fluence increase slightly over the coming UTC weekend in any response to the above, but they should then stabilise ahead of any further fast wind arrival Monday 20 March, which carries a further Slight Chance of generating Active fluence by the end of the four days, but probably peaking midweek UTC. STEREO A does not yet show any fast wind enhancement, implying that any new coronal hole lies at least 24 hours upwind.

MOSWOC REFM suggests a rising trend in the risk of Active in the coming 72 hours, however this remains at least a decade below Active even at peak, which is considered realistic guidance given current evidence from GOES.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	20	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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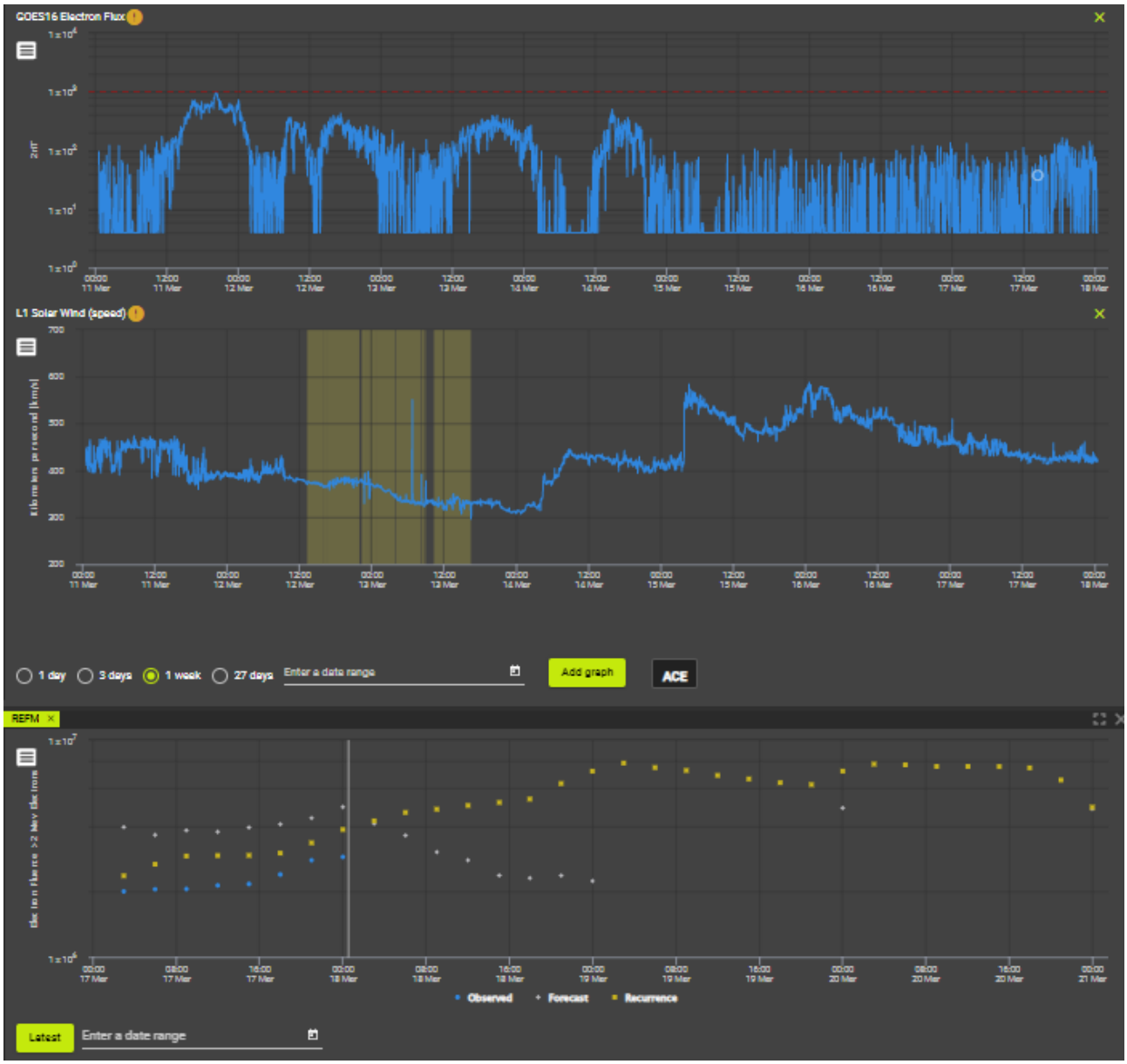
Figure 5: Top: Seven-day GOES16 high energy electron flux observations, showing little response thus far against the once Elevated L1 solar wind (middle plot). Also shown is the MOSWOC REFM fluence forecast, with a weak upward trend suggested and accepted (lowest plot).



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